PUB 42606

PRELIMINARY

Bell System Voice Communications
TECHNICAL REFERENCE

Connecting Arrangement

HZM

Interface Specification

November 1972

ENGINEERING DIRECTOR - CUSTOMER TELEPHONE SYSTEMS

PRELIMINARY

NOTICE

This Technical Reference is published by American Telephone and Telegraph Company as a guide for the designers, manufacturers, and consultants of customer-provided systems and equipment which connect with Bell System communications systems or equipment. American Telephone and Telegraph Company reserves the right to revise this Technical Reference for any reason, including, but not limited to, conformity with standards promulgated by ANSI, EIA, CCITT, or similar agencies; utilization of new advances in the state of the technical arts; or to reflect changes in the design of equipment or services described therein. The limits of responsibility and liability of the Bell System with respect to the use of customer-provided systems and equipment are set forth in the appropriate tariff regulations.

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New York, New York 10007

TECHNICAL REFERENCE

CONNECTING ARRANGEMENT HZM

TABLE OF CONTENTS

LIST OF FIGURES

PRELIMINARY

CONNECTING ARRANGEMENT HZM

1. GENERAL

1.1 Introduction

F.C.C. Tariffs and corresponding intrastate tariffs filed by the Bell System provide for the direct electrical connection of customer-provided equipment and communications systems to Bell System telecommunications network. The tariffs also provide for the indirect (acoustic or inductive) connection of such equipment or systems. Both methods require compliance with network protection criteria given in the tariffs.

Direct electrical connection is made through a connecting arrangement furnished, installed, and maintained by the Telephone Company.

1.2 Application

Connecting Arrangement HZM provides the means for customer-provided traffic measuring equipment to detect supervisory signals, such as, on-hook, off-hook, dial pulse, TOUCH-TONE®, and ringing signals on station lines, PBX C.O. trunks, and some types of tie lines.

Typical applications of this connecting arrangement are shown in Figure 1. Application of this connecting arrangement to trunks associated with Centrex service will be limited to locations where the switching equipment is on the customer's premises. This arrangement cannot be used for recording two way conversations. Such recording is permitted only through Connecting Arrangement RCZ. Connecting Arrangement HZM is not to be used for the transmission of signals into the network.

1.3 Ordering and Identification

The connection service described in this Technical Reference is identified by the Bell System as Connecting Arrangement HZM. One connecting arrangement should be ordered for each station line or trunk which is to be measured by the customer-provided equipment. The local Telephone Company business office or Marketing representative will provide information regarding availability and rates for this service.

2. DESCRIPTION

2.1 Functions

The major functions of this connecting arrangement are:

(a) To protect Telephone Company personnel and facilities from hazardous voltages which may be applied to the connecting arrangement.

(b) To provide isolation from longitudinal imbalance.

(c) To pass dc and ac supervisory and addressing signals on a PBX trunk or station line to customer-provided traffic measuring equipment.

2.2 Physical

Connecting Arrangement HZM consists of a pair of 100,000 ohm tantalum film resistors mounted on a suitable terminal strip (see Fig. 2). Where only a few lines are to be monitored, a simple connecting block mounting will be used (see Fig. 3). Where a number of lines are to be monitored at one location, a rack mounted arrangement will be provided with a separate interface connecting block (see Fig. 4).

2.3 Interface Leads

Two interface leads (1 pair) per circuit are provided from Connecting Arrangement HZM to an interface connecting block. The interface connecting block provided by the Telephone Company will be located within 25 feet of the connecting arrangement equipment. The distance between the connecting arrangement and the customer-provided equipment should be as short as possible to avoid interference between circuits since the terminating impedance is high. The customer must provide and install the conductors and make the necessary connections of his equipment to the voice connecting arrangement at the interface connecting block.

Typical interface connecting blocks are shown in Figs. 3 and 5. The "quick connect" type connecting block shown in Fig. 5 utilizes tin-plated spring clip terminal strips which accommodate unstripped polyethylene or polyvinyl chloride insulated (8 mils maximum thickness) conductors of No. 20 to 24 AWG. A Reliable Electric R714B Tool or equivalent is used to press the insulated wire down into the slot. The spring pressure of the clip cuts away the insulation and makes the electrical connection. The Telephone Company will provide strapping clips between the second and third terminals of the block to interconnect the leads. The clips should be removed by the customer's representative when it is necessary to test toward the customer-provided equipment and then replaced to restore the circuit to service.

3. OPERATION

Connecting Arrangement HZM consists of a pair of resistors connected directly on the telephone facility. The customer-provided equipment

can detect dc and ac voltage conditions on the telephone facility through this isolating resistance.

The voltage conditions that exist on a telephone facility are function of many factors such as the type of central office, type of service (trunk or station line), distance from the central office to the bridging point, and the distance between the bridging point and the station. For this reason, details cannot be given on the exact voltage levels that will be encountered in any particular installation. The loss introduced by the high resistance of Connecting Arrangement HZM will be a function of the internal impedance of the customer-provided detection device.

Paragraphs 4.2 through 4.7 describe in general terms the various conditions that exist on some of the more common types of telephone lines and trunks.

4. SPECIFIC DESIGN CONSIDERATIONS

4.1 General

Connecting Arrangement HZM provides a means for the customer-provided equipment to detect, through 100,000 ohms resistance in each interface lead, the dc and ac status of the trunk at all times, including supervisory and address information (dial pulse and TOUCH-TONE signaling). The supervisory signals consist of "on-hook" indicating an idle or disconnect condition, "off-hook" indicating a request for service by a calling party or an answered call by a called party, "ringing" indicating a party being called, and "switchhook flash" indicating operator recall to a connection. These signals, as well as dial pulse address information, can be detected

as dc voltage level differences across the CT and CR leads. TOUCH-TONE address information consists of two voiceband frequencies for each digit, as discussed in Section 4.12.

The information in the following paragraphs, is not intended to be all inclusive but is intended as a guide to assist designers of equipment that will be used with Connecting Arrangement HZM. In all cases the conditions described are those existing on the line side of the connecting arrangement. The degree to which the values given would be altered by the high resistance of the connecting arrangement is a function of the input impedance of the customer-provided equipment.

4.2 Loop Start Station Lines

This type line is used for central office station and key system service and some PBX trunks. PBX station lines also operate as loop start.

Fig. 6 shows a simplified schematic of a typical loop start central office station line. Connecting Arrangement HZM would be bridged on the line near the station set.

In the standby condition with the station set in the on-hook state, a variety of continuous open circuit dc potentials are present depending on the type of central office switching system. Some older offices (panel) use a battery supply that is nominally -24 volts. The majority of central offices have a -48 volt supply as shown in Figure 6. On some loops range extension equipment may be employed that utilizes 48 V, 72 V, or 96 V dc supplies.

Ringing signals applied at the central office are normally 20 $\pm$ 3Hz ac signals combined with a dc component. Single party ringing

methods include the "ac-dc" method and the "superimposed" method. With ac-dc type of ringing, a nominal 86 V RMS signal is added to a nominal -48 V dc signal and applied to the line through a current sensing device and an interrupter. The interrupter is usually designed to interrupt the ringing voltage for four seconds out of every six second interval, however, other interruption rates are in use. During the silent interval, central office battery is applied to the line. In the superimposed method, central office battery is applied to the line during the silent interval and a lower potential ($\pm$ 38.5 V) is combined with the nominal 86 V RMS ringing signal.

The ac voltages given above are applied at the central office. Figure 7 shows a family of curves giving typical voltages across a bridged ringer. The voltage input to Connecting Arrangement HZM would correspond to these curves when the connecting arrangement is mounted in the vicinity of the telephone set.

In the off hook condition the dc voltage appearing on the line side of the connecting arrangement will be reduced by the battery feed resistance and the resistance of the loop. The loop resistance of most station lines is 1300 ohms or less. However, loop resistances of up to 2500 ohms may be encountered in some cases. The battery feed resistance is generally 400 ohms.

The station line may be exposed to polarity reversals during the progress of a call. The on-hook exchange loop polarity is negative on the ring side and ground on the tip side. The normal exchange loop polarity is applied to the line during the idle condition and to the calling customer's line during dialing and ringing of the called customer's line. Upon answer,

the polarity of the calling party line may or may not be reversed. The called customer's line can have either normal or reversed polarity.

In the process of establishing a talking path, the central office circuit through which dc current is supplied is changed and various line tests are made which can interrupt line current. "Open" is the general term used to describe the condition when no current flows through the loop.

The length of open intervals that a station set can expect to encounter depends on the type of office, class of service, and the progress of the call. Most offices serving single party lines will not generate opens longer than 300 ms. In some offices, the length of the open is traffic-dependent. With old or new systems consecutive switching system initiated opens longer than 100 ms are not expected to occur with less than 100 ms separation.

4.3 Ground Start PBX Trunks

This type of line is used for PBX-CO trunks of the following types:

(a) Two way (combination) DDO - direct dialed outward.

(b) Two-way, attendant handled incoming.

(c) One-way DDO service.

(d) One-way attendant handled incoming.

In some situations, loop start may be used on one way service but in recent years the trend has been to make all PBX trunks ground start.

In the idle condition (on-hook) the tip conductor will be open at the central office and the ring conductor will be connected to -48 volts dc through a ground detection circuit. (Note: Some step-by-step

offices open the ring conductor.) Seizure of the line by the central office for an incoming call to the PBX will apply ground to the tip (ring in some step-by-step offices). Ringing is then applied between the tip and ring conductors. The ringing will normally be "superimposed" as described in paragraph 3.2, although other methods may be encountered. To answer an incoming call the PBX completes the loop circuit.

To seize the line for an outgoing call the PBX places a ground on the ring conductor and the central office responds with a ground on the tip when it is ready to receive dial pulses. The PBX switches from the ground start to the loop mode when the central office tip ground is received.

When the PBX station or attendant goes on-hook at the end of a call originated by the PBX, the loop path is opened by the PBX trunk circuit. The central office will revert to the idle state.

Disconnect from the distant end on incoming calls will normally be indicated by an open on the tip (or ring). Some step-by-step offices do not provide this signal until the called party has gone on-hook.

4.4 Tie Trunks

Tie trunks can be described by their use (2-way, incoming, outgoing), their selection (manual, dial), and their method of signaling (ringdown, automatic, dial repeating). In some of the following word descriptions, certain terms may not be used because they are implied. There are three basic types of PBX tie trunk circuits. These are as follows:

(a) 2-Way Dial: Tie trunk circuits which provide dial selection of the desired station on incoming calls at the terminating end.

(b) 2-Way Automatic: Tie trunk circuits which signal the PBX attendant at the distant end directly upon seizure, without the sending of a 20-Hz ringing signal, and provide answer and disconnect cord signals to both the originating and terminating PBX attendant. Selection of the desired station at the terminating end is done by the PBX attendant.

(c) 2-Way Ringdown: Tie trunk circuits which require the sending of a 20-Hz ringing signal to reach the PBX attendant at the distant end. Neither the originating nor terminating PBX attendant receives answer or disconnect cord signals from the trunk. Selection of the desired station at the terminating end is done by the PBX attendant. Dial selected ringdown trunks and some manually selected ringdown trunks on consoles are arranged to send a single 2-second spurt of 20-Hz ringing upon seizure.

Permutations and one-way only use of these three basic types is possible. One such case is a one-way dial--one-way automatic tie trunk circuits for use between a dial PBX and a manual PBX.

Dial tie trunks use either loop signaling or one of several signal transmission systems that are designed for signaling over long distances. Automatic tie trunks normally use loop signaling, however, several different range extension arrangements may be used.

The most common system for range extension from PBX trunks is DX signaling. Many PBX trunk circuits have the DX signaling units built in.

Ringdown signaling: In ringdown signaling, the ringing voltage (90-105 volts 20 Hz) is applied to the selected tie trunk to alert the distant PBX. This ringing voltage is applied manually by the attendant operating a ring key or automatically when the trunk is dialed. The automatic ringing will normally be applied only one time for a period of about 2 seconds.

Loop Signaling: Loop signaling involves the flow of current over the two conductors of the loop, directly operating a relay or other sensing device to indicate seizure, dial pulsing, disconnect, or other auxiliary signals. The different types of loop signaling are as follows:

High-low signaling uses a change in current to signal origination on locally originated calls or to signal answer on calls originated at the distant PBX. This change in current is produced by changing the loop resistance. If the local PBX has high-low signaling, the distant PBX may have high-low signaling or may have reverse-battery signaling. In a typical signaling sequence, a voltage is applied to the circuit at one PBX to indicate seizure (selection) and a change

in current (by change in loop resistance at the other PBX) to indicate answer.

Reverse-battery signaling uses a reversal of the polarity of potential applied to the loop to signal answer on calls originated at the distant PBX and to signal origination on locally originated calls. A polarized relay is normally used at the distant end; the normally applied polarity of voltage will not energize the relay, but the reversed voltage polarity will. The distant PBX may or may not have the same type of signaling. In a typical signaling sequence, the local PBX seizes the circuit by completing the loop so that a voltage source at the distant PBX causes current to flow in the loop. At answer, the distant PBX reverses the polarity of the applied voltage. To release, the loop is opened by the calling PBX.

Battery and ground signaling is signaling in which a voltage is applied at the distant PBX and the loop at the local PBX is open during the idle condition. To seize the circuit, the local PBX applies a voltage to the loop that is in series and aiding the voltage at the distant PBX. To answer, the distant PBX reverses the polarity of its applied voltage; and to hold the call, the local PBX reverses its voltage polarity. To release the connection, the

loop is opened at the calling PBX. This system is similar to reverse-battery signaling but can operate over a greater range.

DX Signaling: In order to signal over trunk facilities of greater resistance than loop signaling permits, DX signaling is commonly used. The DX signaling circuit (Fig. 8) uses the same cable pair as the talking path. One wire of the pair is used for signaling and the other wire is used for earth potential correction (EPC) and to compensate for any difference in battery voltage between the two PBXs. The DX signaling circuit consists essentially of a polar relay having four windings, a resistor network, and a capacitor network. A circuit is required at each terminal of the trunk circuit. A reference voltage is applied to the junction of the P3 and P4 windings. The value of this reference voltage reflects any ground potential at the terminal and the supply voltage at the terminal. A resistor network of 1250 ohms plus the one-way trunk resistance (RT) between DX units balances the current between the P2 and P3 windings and the P1 winding during operation of the control relay. The capacitor network balances the line capacitance to prevent false operation or flutter of the DX relay when its control relay operates. The control relay is not part of the DX unit but connects to ground when idle and to battery supply when busy. During pulsing, the control relay follows the dial pulses. There are four conditions that the two connecting DX signaling units can have:

(1) Both control relays unoperated: A bias current will flow through windings P2 and P3 of both relays to keep

them unoperated. Any difference in ground potential between the near and far ends will cause a current through winding P1 at each end. This current will tend to operate the relay at one end and keep the relay unoperated at the other end. The EPC current, caused by the reference voltage differences, flows through the P4 windings of each relay, canceling the effects of any current through the P1 windings.

(2) The near end control relay operated: The current through the near end winding P2 and P3 will tend to operate the relay, but the current through its P1 winding will more than cancel this effect. At the far end the current through the P1 winding is sufficient to overcome the effects of the current through the P2 and P3 windings and will cause the far end relay to operate for a one-way trunk resistance (RT) up to 5000 ohms.

(3) The far end control relay operated: The condition is the same as in (2) except the near end and far end are reversed.

(4) Both control relays operated: If both control relays are operated, the current through P1 will be due to the supply voltage difference between the two ends and will be cancelled by the EPC current

through winding P4. The current through windings P2 and P3 is sufficient to cause the DX relay to operate. The same action occurs at both ends.

Additional information on tie trunks may be found in the Transmission Technical Reference "Private Line Interconnection - Voice Applications" PUB 43201 dated June, 1970.

4.5 DC Dial Pulse Signaling

In general, dc dial pulses are generated at a nominal rate of 10-pulses per second, with a minimum of 8- and a maximum of 11- pulses per second. Some PBX trunks may use 20 pulses per second. The percent break varies from 50 percent to 64 percent. The minimum interdigital time is 600 milliseconds.

4.6 TOUCH-TONE Address Signaling

The signaling code for the Bell System TOUCH-TONE calling system provides for 16 distinct signals. Each signal is composed of two voice-band frequencies, one from each of two mutually exclusive frequency groups of four frequencies each. The signal frequencies are spaced and selected on the basis that the two frequencies of any valid signal combination are not harmonically related. The frequency pairs assigned for the signaling are as follows:

		Nominal High Group Frequencies (Hz)			
		1209	1336	1477	1633
Nominal	697	1	2	3	Spare
Low Group	770	4	5	6	Spare
Frequencies	852	7	8	9	Spare
(Hz)	941	*	0	#	Spare

These address signals can be expected to have the following characteristics at the originating station:

A. Frequency Deviation

Tone frequencies are within ±1.5 percent of their nominal values.

B. Voice Energy Suppression

Voice energy from the telephone transmitter or other source is suppressed at least 45 dB below the signal power measured at the telephone set during tone signal transmission. In the case of automatic dialing, the suppression is maintained continuously until pulsing is completed.

C. Rise Time

Each of the two frequencies of the signal attains at least 90 percent of full amplitude within 5 ms, and within 3 ms for automatic dialers, from the time that the first frequency begins.

D. Pulsing Rate

Minimum duration of	
two-frequency tone signal:	50 ms
Minimum interdigital time:	45 ms
Minimum cycle time (period):	100 ms

4.7 DDD Network Characteristics

The structure and operation of the DDD network is described in Data Communications Technical Reference "Data Communications Using the Switched

Telecommunications Network" (PUB 41005), which may be obtained as described in Appendix C.

5. REQUIREMENTS FOR CUSTOMER-PROVIDED EQUIPMENT

5.1 Internal Impedance and Balance Requirements

The customer-provided detection device must present an impedance of at least 100,000 ohms to ground when measured at lead CT and CR. The customers equipment must be balanced within 5%, i.e., the impedance from CT to ground shall not differ for the impedance from CR to ground by more than 5,000 ohms.

Balanced operation will insure that the customer-provided equipment is not subjected to noise caused by longitudinal currents that may be present on the telephone facility.

5.2 Foreign and Surge Voltage Protection

Where telephone lines are exposed to foreign voltages by direct contact or induction (e.g., power line crosses or lightning), protective devices are installed at the Central Office and at the PBX that will provide a path to ground for foreign voltages that exceed about 600 volts peak. Since the customer's equipment is connected to the telephone line through the connecting arrangement, the customer's equipment is protected from longitudinal and metallic surges by high resistance isolation consisting of 100,000 ohms bridged separately across the Tip and Ring conductors.

The customer is responsible for providing protection, internal to his equipment and facilities, against foreign and hazardous voltages from his equipment and facilities being applied to the connecting arrangement.

5.3 Grounding

It is expected that the customer's equipment, if powered from commerical power, will be grounded in accordance with applicable electrical codes (NEC) and should be bonded to the ground electrode to which the telephone protector is grounded but not using the telephone ground clamp. Self-powered or passive customer's equipment need not be grounded. Provisions should be made within the customer's equipment for connecting together all internal signal grounds. This connection shall be isolated from both the grounding (green) conductor run with the power supply primary conductors and the chassis or frame of the customer-provided equipment.

The customer's signal ground may be obtained with a proper connection to a metallic cold water pipe, using a single No. 14 AWG, or larger copper conductor. The other end should be connected to the ground return terminal of the customer's equipment. The run should be short, straight, and a continuous piece of wire. Proper attention should be given to providing the lowest possible resistance connection at each end of the circuit. It is imperative that this ground be connected at the same location to the water piping system or ground electrode as the telephone protector or signal ground lead but not using the Telephone Company ground clamp. This lead shall not be fused.

6. SERVICE AND MAINTENANCE CONSIDERATIONS

6.1 Responsibility of the Customer

The Tariffs permitting connection of customer-provided terminal equipment or communications systems state that where private line or long

distance message telecommunications service is available under these Tariffs for use in connection with terminal equipment or communications systems, provided by a customer, the operating characteristics of such equipment or systems shall be such as not to interfere with any of the services offered by the Telephone Company. Such use is subject to the further provisions that the equipment or systems provided by a customer does not endanger the safety of Telephone Company employees or the public; damage, require change in or alteration of, the equipment or systems or other facilities of the Telephone Company, interfere with the proper functioning of such equipment or systems or facilities, impair the operation of the telecommunications system of facilities or otherwise injure the public in its use of the Telephone Company's services. Upon notice from the Telephone Company that the equipment or system provided by a customer is causing or is likely to cause such hazard or interference, the customer shall take such steps or make such change as shall be necessary to remove or prevent such hazard or interference.

6.2 Responsibility of the Telephone Company

The Tariffs permitting connection of terminal equipment and communications systems, provided by a customer, state that the Telephone Company shall not be responsible for the installation, operation or maintenance of said terminal equipment or communications systems. Private line or long distance message telecommunications service is not represented as adapted to the use of customer-provided equipment or systems and where such equipment or systems are connected to Telephone Company facilities, the responsibility of the Telephone Company shall be limited

to the furnishing of facilities, including the protective connecting arrangements and network control signaling units, suitable for private line or long distance message telecommunications service and to the maintenance and operation of such facilities in a manner proper for such services. Subject to this responsibility the Telephone Company shall not be responsible for (i) the through transmission of signals generated by the customer-provided equipment or systems or for the quality of, or defects in, such transmission, or (ii) the reception of signals by customer-provided equipment or systems or (iii) address signaling where such signaling is performed by customer-provided tone type signaling equipment. The Telephone Company shall not be responsible to the customer if changes in minimum network protection criteria contained in the Tariffs (and in this Technical Reference) or in any of the facilities, operations or procedures of the Telephone Company render any customer-provided facilities obsolete or require modification of alteration of such equipment or systems or otherwise affect its use or performance.

6.3 Trouble Reporting Procedure

When trouble is experienced with this service, the customer should perform the necessary testing at the interface to sectionalize the difficulty, i.e., determine whether the service impairment is located in the customer-provided equipment or in the equipment provided by the Telephone Company. If the tests indicate that the trouble is in the Telephone Company-provided equipment, it should be promptly reported to the Telephone Company. Trouble reports should be called into the listed "Repair

Service" number which can be found in the front of the telephone directory. The repair attendant should be given:

(a) Customer's name

(b) Customer's address

(c) Listed telephone number

(d) Description of the trouble

(e) Customer's contact for additional information

If a Telephone Company service call results in the location of the trouble in the customer-provided equipment, the customer will be charged for the service call.

APPENDIX A

GLOSSARY

ADDRESS SIGNALS - denotes dc dial pulses or appropriate pairs of TOUCH-TONE signals transmitted to a Central Office that represent the telephone number of the distant party.

CONNECTING ARRANGEMENT - equipment provided by the Telephone Company to accomplish the electrical connection of customer-provided equipment and the telecommunications network.

CUSTOMER - denotes the person, firm or corporation which orders service and is responsible for the payment of charges and compliance with Telephone Company regulations.

CUSTOMER-PROVIDED EQUIPMENT - devices or apparatus and their associated wiring, provided by a customer, which do not constitute a communications system and which, when connected to Telephone Company equipment, are so connected either electrically, acoustically, or inductively.

DIAL PULSE RATE - repetition of pulses for switching purposes, usually expressed in pulses-per-second.

INTERDIGITAL TIMING - the minimum time required between digits for the switching equipment to respond to the last digit received and ready itself for receiving the next digit.

INTERFACE CONNECTING BLOCK - the Telephone Company-provided connecting point to which the customer brings and connects the leads of his equipment and to which the Telephone Company brings and connects leads from the connecting arrangement.

NETWORK CONTROL SIGNALING - denotes the transmission of signals used in the telecommunications network which perform functions such as supervision (control, status, and charging signals), address signaling (dialing, both rotary and tone signaling), calling and called number identification, audible tone signals (call progress signals indicating reorder or busy conditions, alerting, coin denominations, coin collect and coin return tones) to control the operation of switching machines in the telecommunications network.

OFF-HOOK SUPERVISION - indicates that the telephone is answering or originating a call.

ON-HOOK SUPERVISION - indicates that the telephone has disconnected or that the equipment is idle.

PERCENT BREAK - the period of time of an open interval in a dial pulse sequence compared to the total time of an open and closed interval, expressed as a percentage.

SUPERVISORY SIGNALS - signals used to initiate a request for service by the calling party (off-hook); to notify the called party that he is being called (ringing); to indicate an answered call (off-hook); to indicate a disconnect (on-hook); and to recall an operator or distant party to a connection (switchhook flash).

TELECOMMUNICATIONS NETWORK - the Bell System voice switching equipment, associated interconnecting facilities, and station equipment which provide Long Distance Message Telecommunications service or private line service.

TELEPHONE COMPANY - denotes the American Telephone and Telegraph Company, the Long Lines Department, its concurring carriers, and its connecting carriers, either individually or collectively.

PRELIMINARY

APPENDIX B

REFERENCES

Some references describing various transmission characteristics of the telecommunications network are listed below:

(a) McAdoo, K. L., "Speech Volumes on Bell System Message Circuits - 1960 Survey," Bell System Technical Journal (BSTJ), Vol. 42, No. 5 (September 1963), p. 1999.

(b) Gresh, P. A., "Physical and Transmission Characteristics of Customer Loop Plant", BSTJ, Vol. 48, No. 10 (December 1969), p. 3337.

(c) Bell System Data Communications Technical Reference - PUB 41007 1969 - 1970 Switched Telecommunications Network Connection Survey (Reprints of Bell System Technical Journal Articles) - April 1971.

(d) Breen, C., and Dahlbom, C. A., "Signaling Systems for the Control of Telephone Switching," BSTJ, Vol. 39, No. 6 (November 1960), p. 1381.

(e) Bodle, D. W., and Gresh, P. A., "Lightning Surges in Paired Telephone Cable Facilities," BSTJ, Vol. 40, No. 2 (March 1961), p. 547.

*(f) "Principles of Electricity Applied to Telephone and Telegraph Work" by American Telephone and Telegraph Company, New York, New York.

*(g) "Switching Systems," by American Telephone and Telegraph Company, New York, New York.

*(h) "Notes on Transmission Engineering," by United States Independent Telephone Association, Washington, D. C.

*(i) "Transmission Systems for Communications," by Bell Telephone Laboratories, Inc.

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*Available through Western Electric Company, Inc.
Commercial Relations
P. O. Box 1579
Newark, New Jersey 07102

APPENDIX C

WHERE TO OBTAIN REFERENCE MATERIAL

1. Bell System Technical References

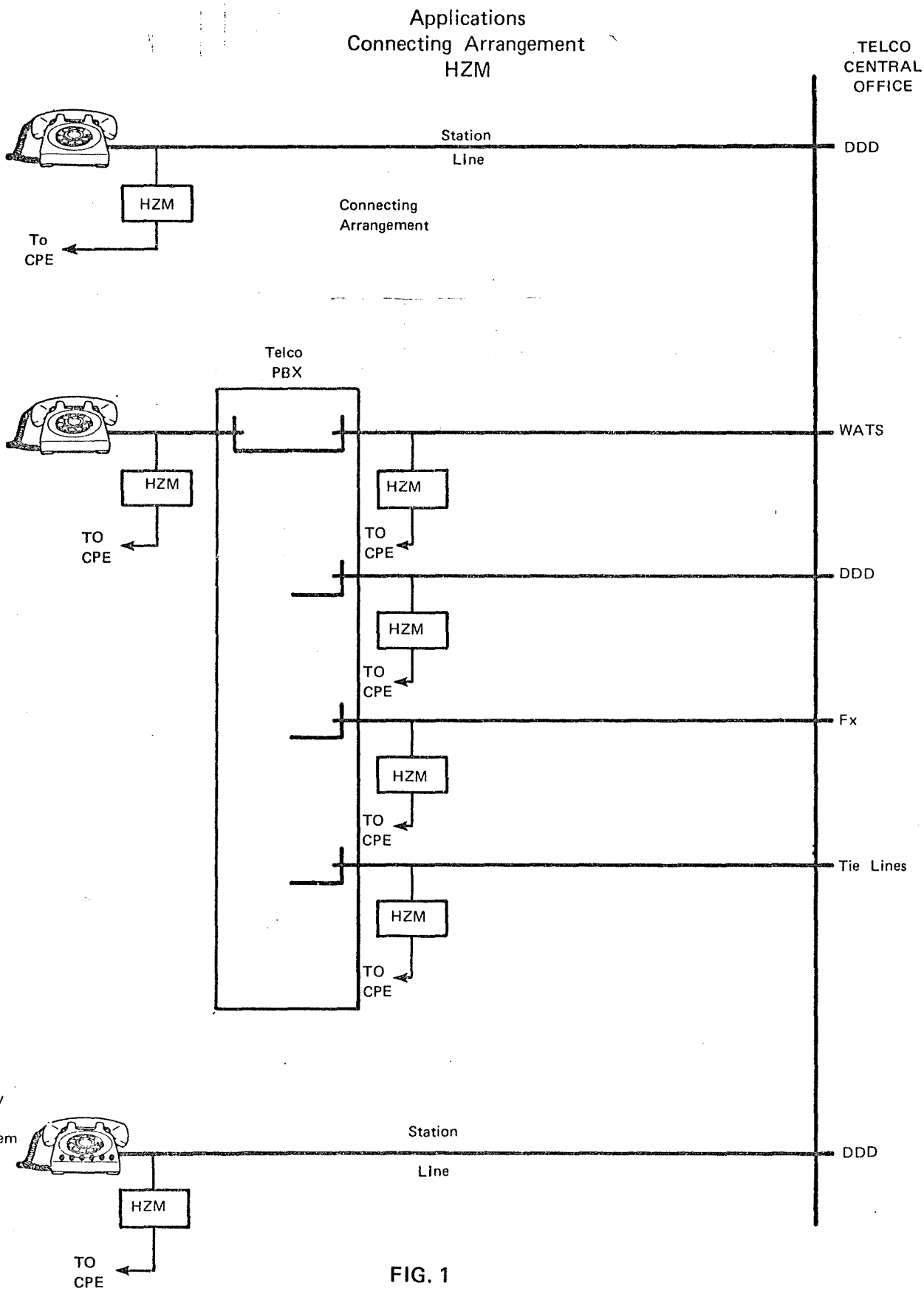
These references may be purchased by writing to:

American Telephone and Telegraph Company
Supervisor - Information Distribution Center
195 Broadway, Room 208
New York, New York 10007

2. Bell System Technical Journals (BSTJ)

These journals may be purchased by writing to:

Mr. F. J. Schwetje
Bell Telephone Laboratories, Inc.
Mountain Avenue, Room 3C115
Murray Hill, New Jersey 07974


Applications
Connecting Arrangement
HZM
TELCO
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OFFICE
Station
Line
DDD
HZM
Connecting
Arrangement
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CPE
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PBX
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CPE
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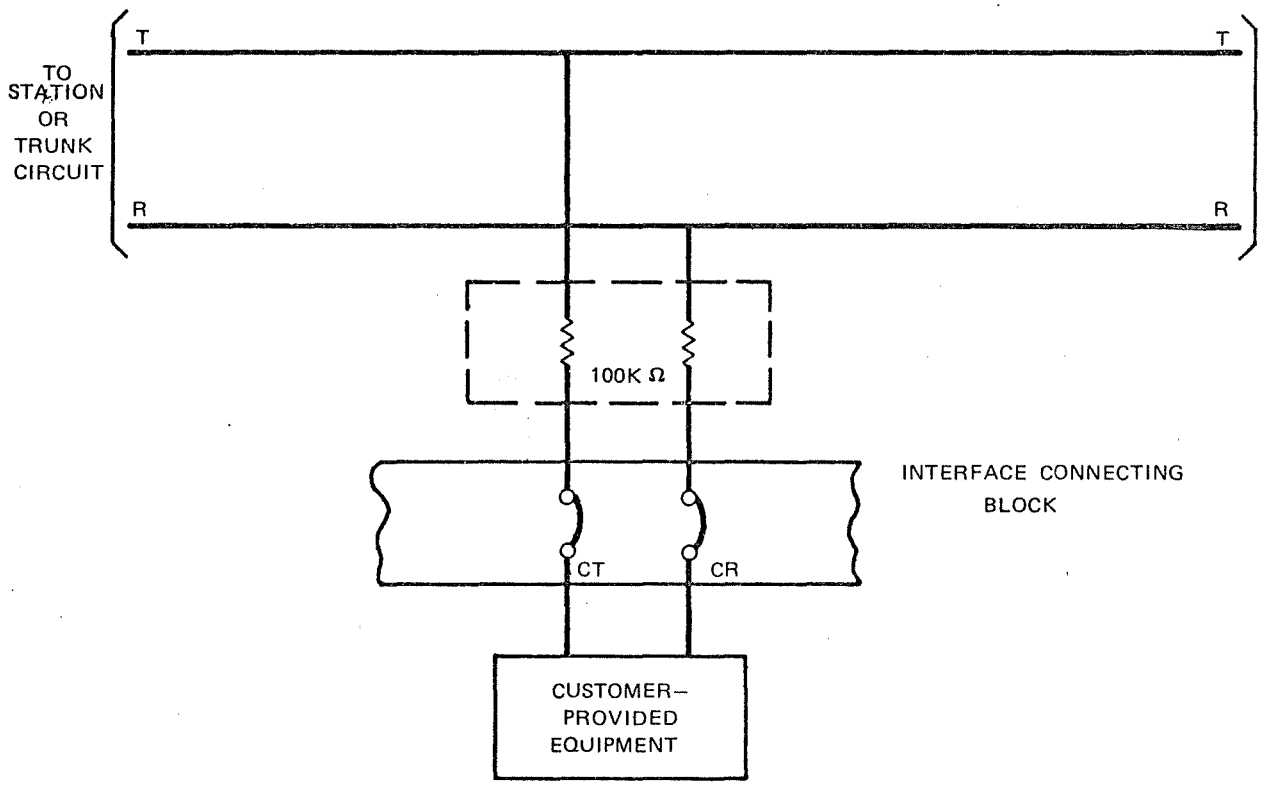
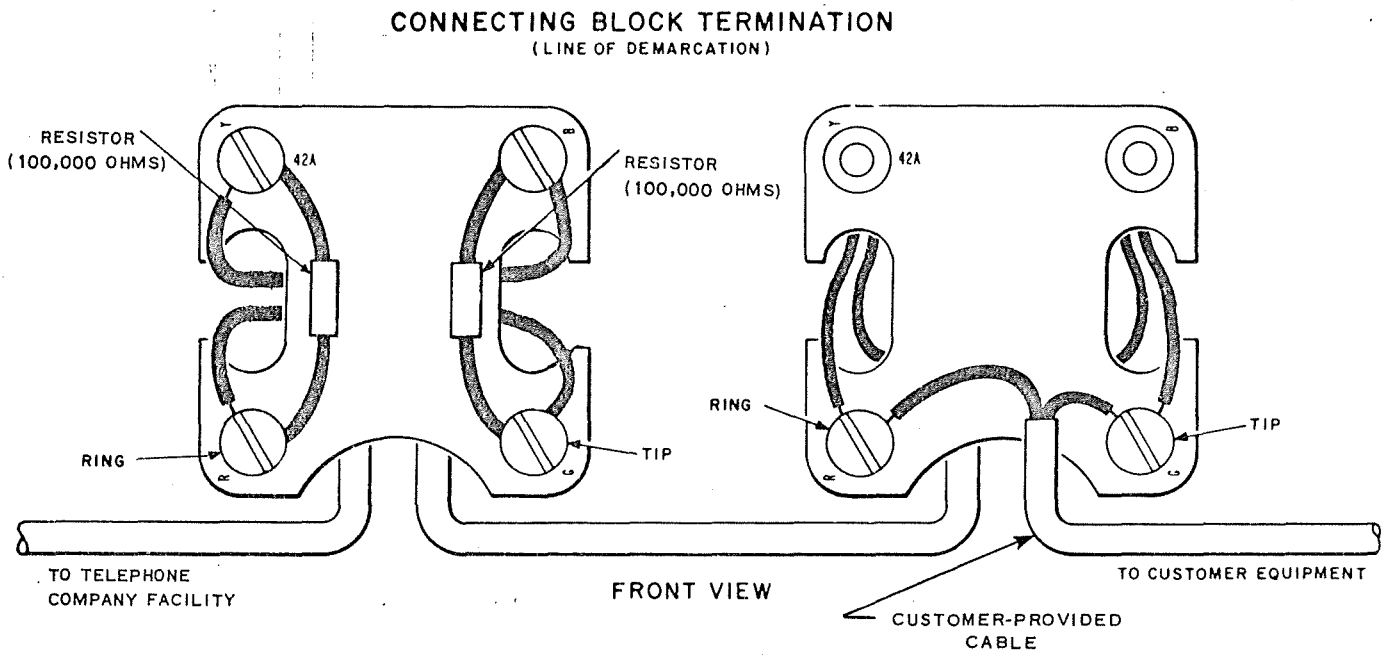
FIG. 1



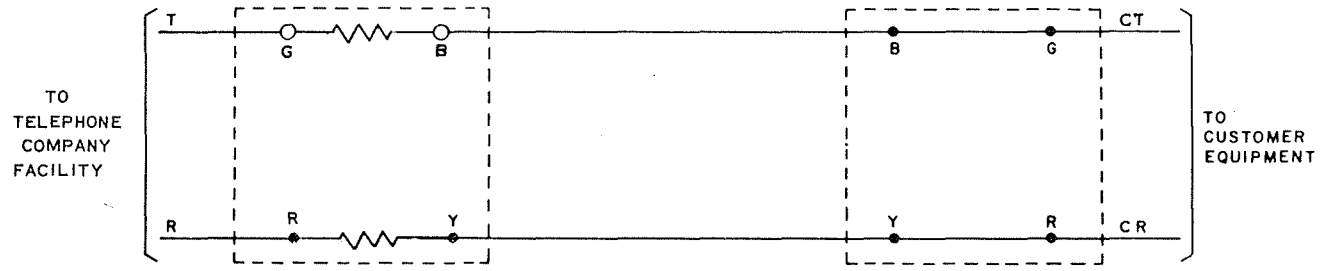
CONNECTING ARRANGEMENT

HZM

FIG. 2

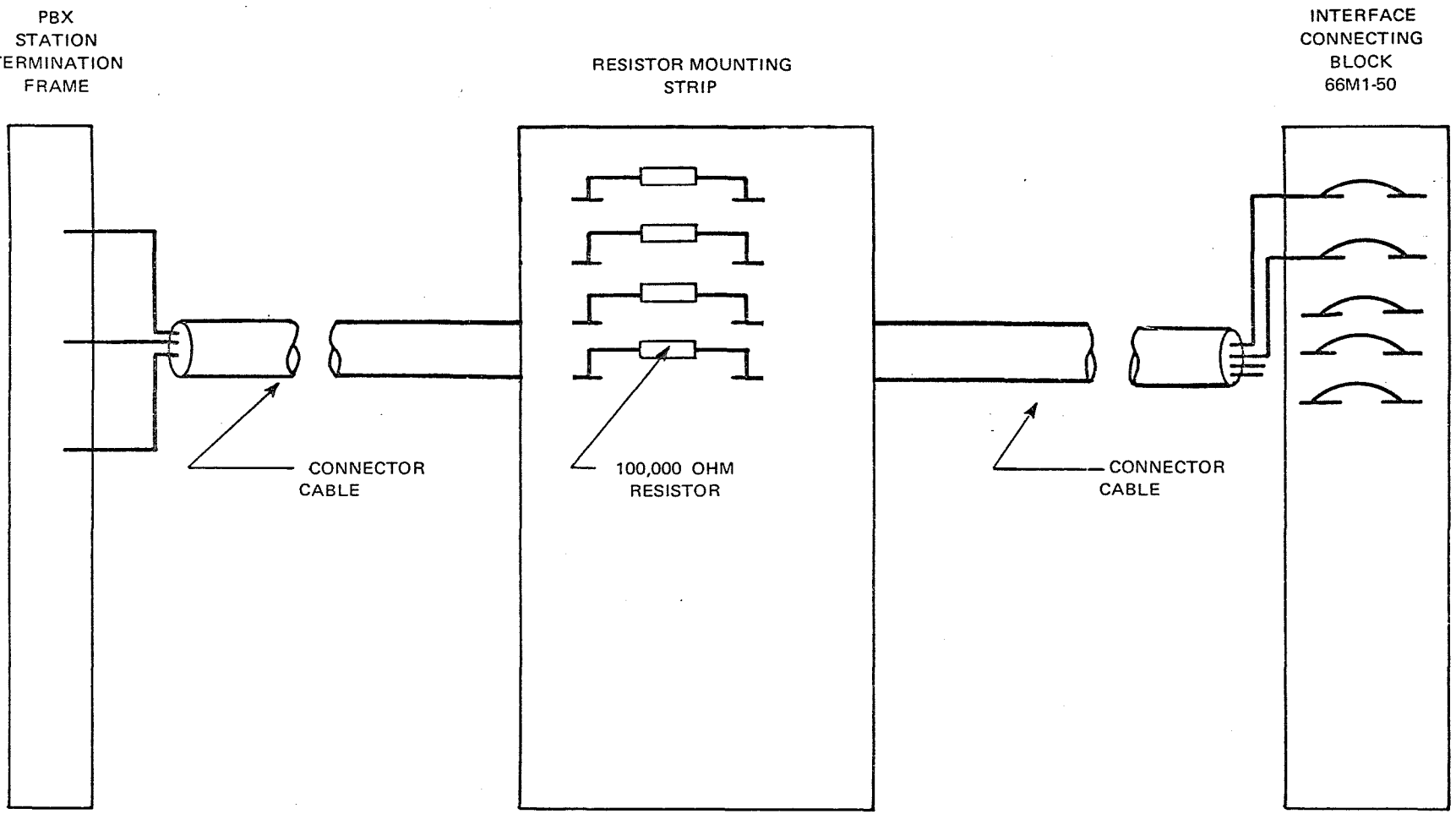


NOTE: THIS MOUNTING ARRANGEMENT WILL BE USED WHERE ONLY A FEW CONNECTING ARRANGEMENTS ARE REQUIRED AT ONE LOCATION



TYPICAL MOUNTING ARRANGEMENT
CONNECTING ARRANGEMENT HZM

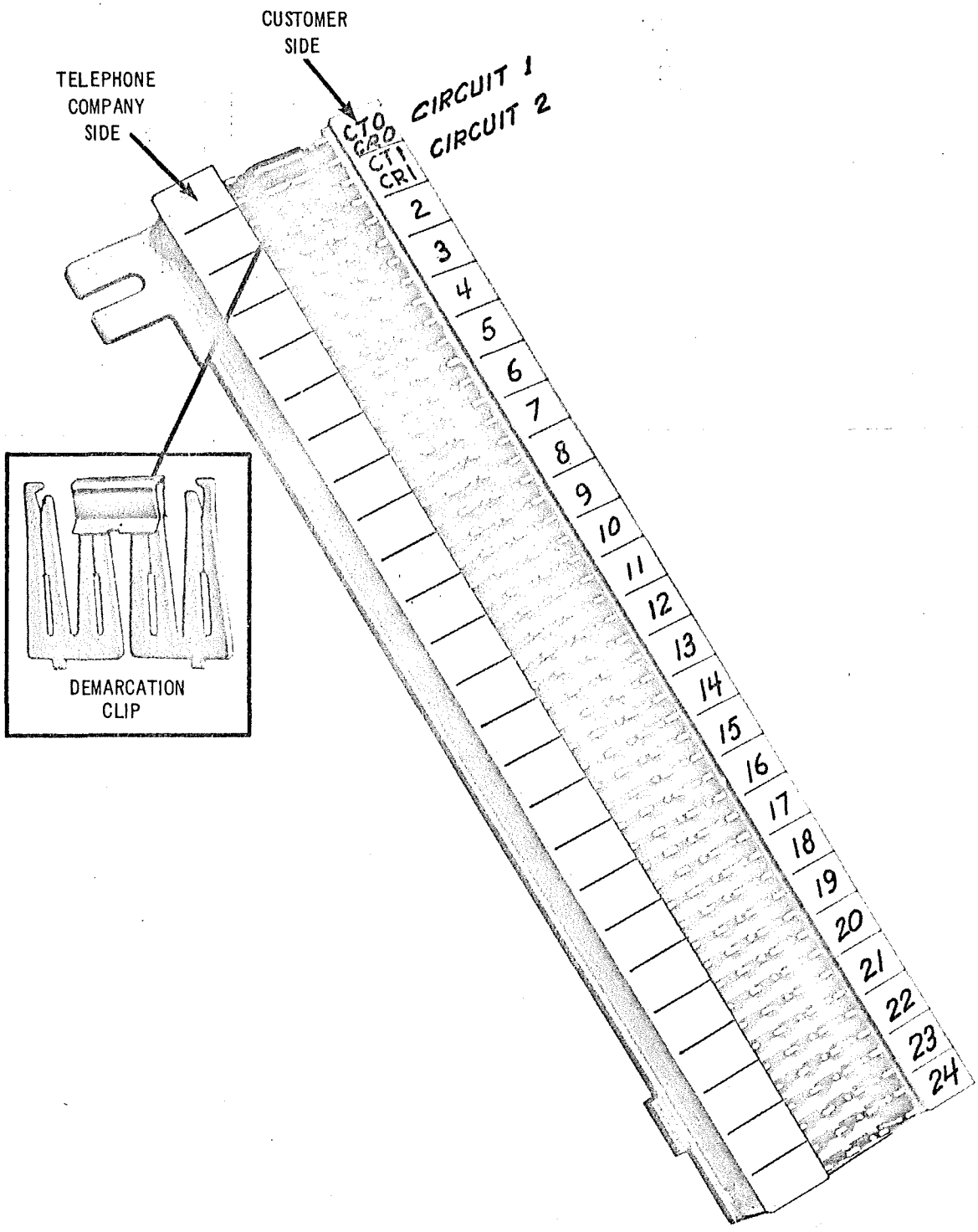
FIG. 3



TYPICAL MOUNTING ARRANGEMENT – CONNECTING ARRANGEMENT HZM

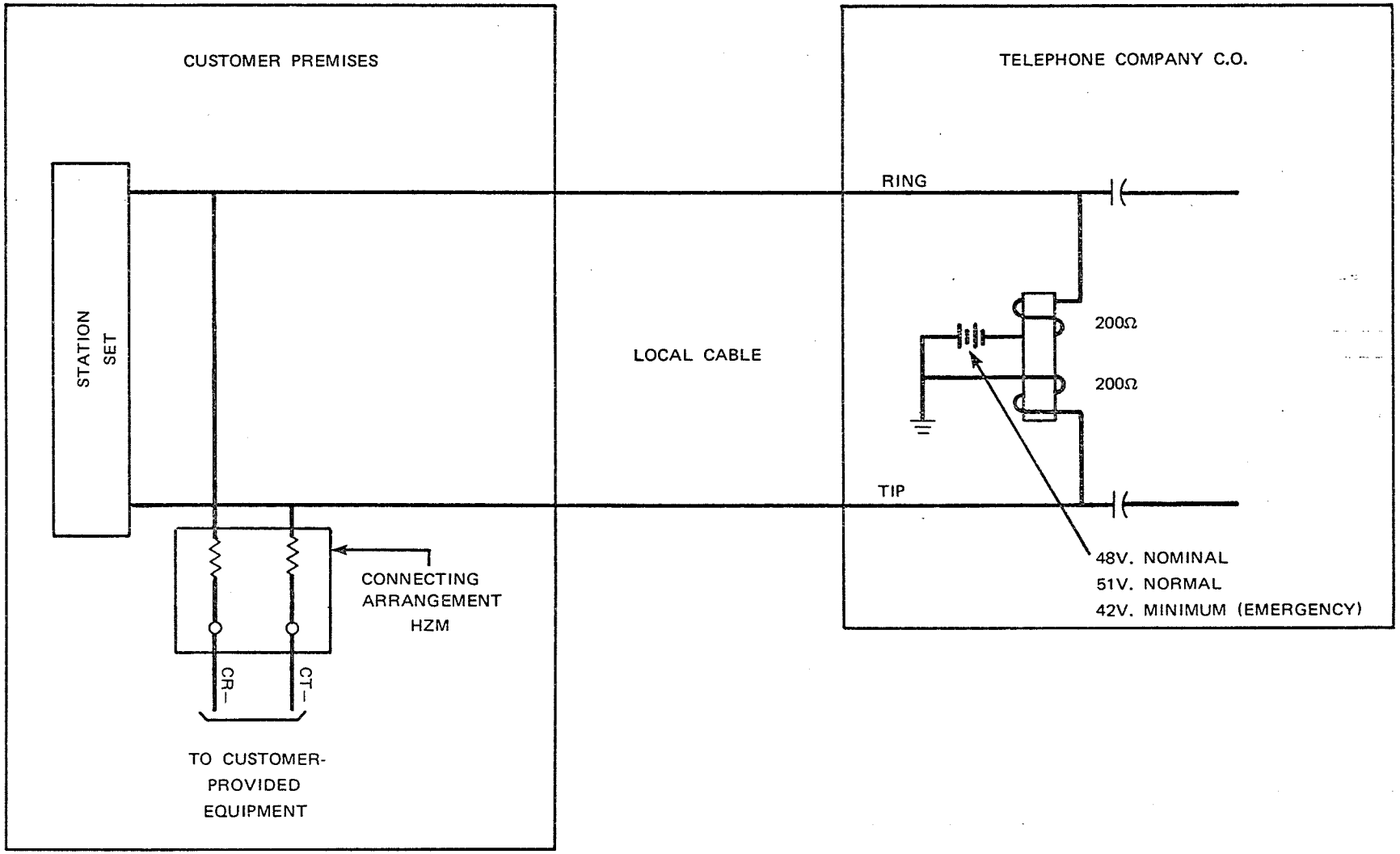
FIG. 4

PRELIMINARY



TYPICAL INTERFACE CONNECTING BLOCK

FIG. 5



TYPICAL CENTRAL OFFICE
BATTERY FEED CIRCUIT

FIG. 6

PRELIMINARY

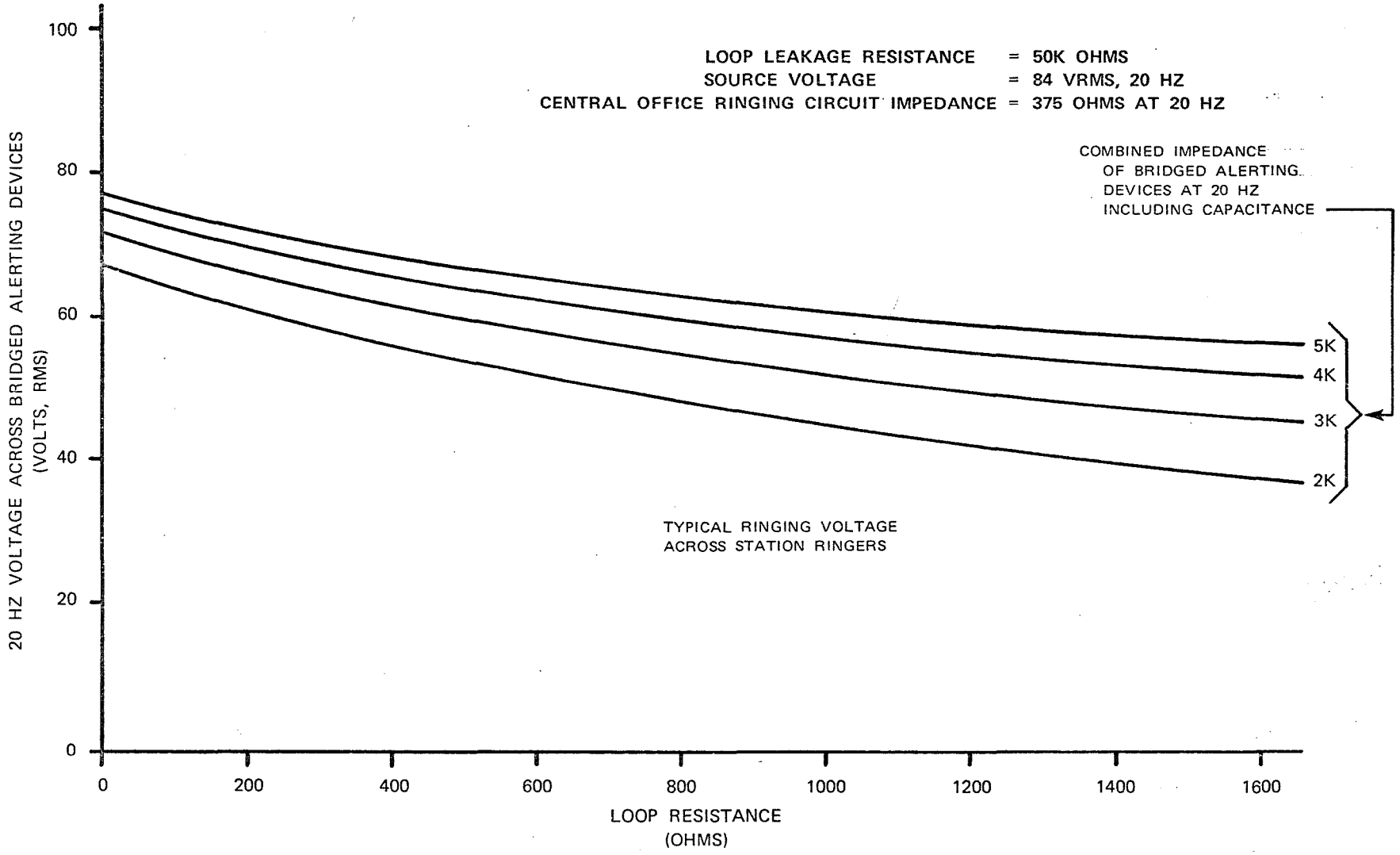


FIG. 7

PRELIMINARY